

Name :

Roll No. :

Invigilator's Signature :

CS/M.TECH (BT)/SEM-1/MBT-115D/2011-12

2011

**ADVANCES IN BIOREACTOR DESIGN,
DEVELOPMENT AND SCALE-UP**

Time Allotted : 3 Hours

Full Marks : 70

The figures in the margin indicate full marks.

*Candidates are required to give their answers in their own words
as far as practicable.*

GROUP – A

(Multiple Choice Type Questions)

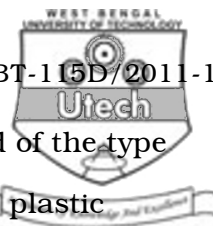
1. Choose the correct alternatives for any *ten* of the following :

10 × 1 = 10

- i) A reactor may be assumed as plug flow if the flow is
 - a) laminar
 - b) turbulent
 - c) streamline
 - d) viscous flow.
- ii) RTD curve due to pulse input gives rise to
 - a) asymptotic curve
 - b) hyperbolic curve
 - c) bell-shaped curve
 - d) normal distribution curve.



- iii) Volumetric mass transfer coefficient, K_{La} , for Bubble column is given as a function of
- a) P/V
 - b) V_{gs}
 - c) Re_I
 - d) Combination of (a) & (b).
- iv) Anti-biotics are best produced in , type of the reactor.
- a) Packed bed
 - b) Bubble column
 - c) CSTR
 - d) Air-lift fermenter.
- v) The kinetics of vaccine production is based on the model of
- a) growth associated
 - b) non-growth associated
 - c) a combination of (a) and (b)
 - d) Monod model
- vi) Low flow rate of a gas is measured by
- a) rotameter
 - b) Orificemeter
 - c) wet gas meter
 - d) thermo-anemometer.
- vii) Trickle bed reactor is characterized by
- a) mass transfer
 - b) low L/D ratio
 - c) combination of (a) and (b)
 - d) small flow rate of liquid.



- viii) Cell suspension is a non-Newtonian fluid of the type
- Bingham plastic
 - Pseudo plastic
 - Dilatant
 - Cassar equation.
- ix) Monod Model behaves as a reaction of the type for small substrate concentration.
- first order
 - zero order
 - second order
 - pseudo first order.
- x) Perfusion reactor is used for the production of
- antibiotics
 - alcohol
 - monoclonal antibodies
 - single cell protein.
- xi) The criterion for the selection of animal cell culture reactor is
- low shear rate
 - removal of toxic metaolites
 - combination of (a) and (b)
 - high cell mass concentration.
- xii) The scale-up criterion for a CSTR to be used for animal cell culture is based on
- geometric similarity
 - equal P/V
 - equal tip velocity
 - equal impeller based Reynolds No., Re_I



GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following.

$3 \times 5 = 15$

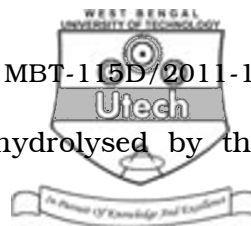
2. In a CSTR, efficient mixing is achieved if the eddy size, created by a turbine impeller is approximately $80 \mu\text{m}$. The impeller diameter, $D_I = 0.3 \text{ m}$.

Calculate the power to be generated by the stirrer for desired degree of mixing. Given, $\lambda = \left(\frac{\gamma}{\mu} \right)^{1/4}$, where γ is the kinematic viscosity of the liquid, μ is the energy dissipated per unit mass of the fluid.

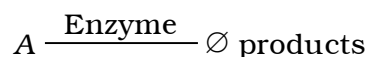
$$\mu = 1 \times 10^{-3} \text{ Pas and } \rho (\text{ density }) = 1000 \text{ kg/m}^3 .$$

3. Describe the important features of a stirred tank reactor with respect to efficient mixing.
4. The scaled-up volume of a reactor is 100 m^3 from 0.1 m^3 reactor with $L/D = 3$. The impeller diameter, $D_I = 0.3 D$.

If the agitator speed of the small reactor is 600 rpm, what is the agitator speed of the bigger reactor, on the basis of equal mixing time, t_m ?



5. At room temperature sucrose (A) is hydrolysed by the enzyme sucrase (E) as follows :



Given data :

$C_A \text{ (mol./m}^3\text{)}$	0.68	0.16	0.006
$t, \text{ hr}$	2	6	10

At $t = 0$, $C_{Ao} = 1.0 \text{ mole/m}^3$, $C_{Eo} = 0.01 \text{ mole/m}^3$.

The rate equation is $-\frac{dC_A}{dt} = \frac{V_{max} C_A}{K_m + C_A}$

Linearise the rate equation after integration to find v_{max} and K_m (the kinetic parameters) .

6. Derive the following relation from Michaelis-Menten Enzyme kinetic relation :

$$V_{max} t = S_o - S + K_m \ln S_o / S$$

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. a) A Bubble Column reactor of volume 1 m^3 $\left(\frac{L}{D_t} = 5 \right)$ is agitated by sparging air from the bottom at the rate of $0.02 \text{ m}^3/\text{s}$ at 1.08 bar and 25°C . The sander mean diameter of bubbles is $D_{32} = 3 \text{ mm}$ and hold-up, $\square_G = 0.05$. Calculate the following
- i) bubble rise velocity, m/s



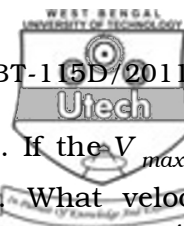
ii) interfacial area, a (m^2 / m^3)

iii) volumetric mass transfer coefficient, k_{La} , given

$$k_{La} = 0.32 (v_{gs})^{0.7} \text{ sec}^{-1}.$$

- b) Describe the operation of an air-lift fermentor which is to be used for animal cell culture. 8 + 7
8. a) How do you correlate the cell mass growth with oxygen consumption in terms of kinetic parameters and volumetric mass transfer coefficient k_{La} ?
- b) The volumetric mass transfer coefficient, k_{La} of a small bubble column reactor (2 L) has been measured as 15 hr^{-1} at an airflow rate of 4 l/min. If the rate of oxygen uptake by a culture of some plant cells is $0.2 \text{ mmol (g.dry wt) (hr)}$ and the critical oxygen concentration is 10% of the saturation (8 ppm). What is the maximum concentration of cells that can be maintained in the reactor ? 7 + 8
9. a) What are the methods of modelling non-ideal reactors ? Describe the tanks-in-series model with its performance equation assuming first order kinetics.
- b) What are the merit and demerits of a hollow fibre reactor for animal cell culture ? 8 + 7
10. a) What is power law model to be used for Non-Newtonian fluids ? Classify the types of Non-Newtonian fluids by drawing shear stress (τ) and shear rate ($\dot{\gamma}$) diagram.
- b) Small laboratory PFR gives 80% conversion of A for a first order reaction of the type, $A \rightarrow R$, with residence time, $T = 15 \text{ mins}$. If the same reaction is carried out in a large reactor whose tracer data due to pulse input tracer gave $\sigma_B^2 = 0.2$ and $E = 15 \text{ min}$. Calculate X_A from dispersion model for small deviation for plug flow.

7 + 8



11. a) An enzyme has a k_m of 4.7×10^{-5} M. If the V_{max} of the preparation is 22μ mole/lit min. What velocity would be observed in the presence of 2×10^{-4} M substrate and 5×10^{-4} M of (a) a competitive inhibitor, (b) a non-competitive inhibitor, (c) an uncompetitive inhibitor k_i in all three cases is 3×10^{-4} M. (d) What is the degree of inhibition in all three cases ?
- b) What is the relative activity and degree of inhibition caused by a competitive inhibitor when $[S] = k_m$ and $[I] = k_i$? 10 + 5
12. a) One microgram of a pure enzyme (MW = 92,000) catalyzed a reaction at a rate of 0.50μ moles/min under optimum conditions. Calculate (a) the specific activity of the enzyme in terms of units/mg protein and units/mole, and (b) the turnover number, (c) how long is one catalytic cycle ?
- b) An enzyme was assayed at an initial substrate conc. of 2×10^{-5} M. In 6 min. half of the substrate had been used. The k_m for the substrate is 5×10^{-3} M. Calculate k , v_{max} and conc. of product produced after 15 min.
- c) $A \rightarrow R$, $-r_A = \frac{200 C_A C_{Eo}}{2 + C_A}$, in a batch reactor
 $C_{Eo} = 0.001$ mol/lit, initial enzyme conc.
 $C_{Ao} = 10$ mol/lit.
 Time required for the conc. of reactant to drop to 0.025 mol/lit. 5 + 5 + 5
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